REMARKS

I. Status of Claims

In the first office action dated April 24, 2006, claims 1-20 were rejected by the Examiner. In response to the office action dated April 24, 2006, an amendment was filed with the Office on May 23, 2006 amending claims 1, 2, 14, 17 and 20. A Final office action was then issued by the Examiner dated July 21, 2006 in which claims 1-20 were again rejected. In response to the Final office action dated July 21, 2006, an amendment and RCE (Request for Continued Examination) were filed with the Office on August 15, 2006 in which claims 1, 5, 10, 14, 15, 16, 17, 18, 19, 20 were amended, claims 14 and 18 cancelled, and newly submitted claims 21-23 were presented.

The Examiner then provided a non-final office action dated October 25, 2006 in which claims 1-13, 15-17 and 19-23 remained rejected. In response to the non-final office action dated October 25, 2006, the Applicant filed an amendment with the office on December 18, 2006. The Examiner provided another final rejection on March 2, 2007 again rejecting 1-13, 15-17 and 19-23. The Applicant is responding with the present amendment and remarks and a second RCE in which claims 1-13, 15-17 and 19-23 are cancelled by amendment and new claims 24-44 are presented for consideration. The Applicant submits that the Examiner's previous rejections and arguments with respect to claims 1-13, 15-17 and 19-23 are rendered moot in light of the cancellation of claims 1-13, 15-17 and 19-23. Clams 24-44 are therefore pending as of the date of the present amendments.

II. McHardy

In prior office actions, the Examiner cited McHardy (U.S. Patent No. 5,315,162) as a basis for rejecting Applicant's claims. McHardy, however, does not

anticipate, disclose, teach or suggest all of the following claim limitations of Applicant's amended claim 24:

An electromechanical neural network system based on nanotechnology, comprising:

an adaptive synaptic element comprising a plurality of nanoconductors suspended and free to move about in a liquid dielectric solution located within a connection gap formed between at least one pre-synaptic electrode and at least one post-synaptic electrode, wherein said liquid dielectric solution comprises a mixture of said plurality of nanoconductors and a dielectric solvent, wherein said liquid dielectric solution possesses an electrical conductance that is less than an electrical conductance of said plurality of nanoconductors suspended in said liquid dielectric solution;

a plurality of interconnected nanoconnections associated with said connection network, said plurality of interconnected nanoconnections comprising said plurality of nanoconductors in said liquid dielectric solution, said plurality of interconnected nanoconnections electrically connecting said at least one pre-synaptic electrode to said at least one post-synaptic electrode through said liquid dielectric solution and said plurality of nanoconductors disposed within said liquid dielectric solution; and

a voltage mechanism for applying an electric field across said connection gap, whereby said electric field induces a dipole in each nanoconductor among said plurality of nanoconductors only when said plurality of nanoconductors is located within said liquid dielectric solution, thereby aligning said plurality of nanoconductors within said liquid dielectric solution and strengthening or weakening each nanoconnection among said plurality of interconnected nanoconnections according to an application of said electric field across said connection gap so that said electromechanical neural network system adapts itself to the requirements of a given situation regardless of the initial state of said plurality of interconnected nanoconnections.

Applicant's amended claims thus refer to an electromechanical physical neural network system. **McHardy:** abstract, L1-4; C1, L8-12, on the other hand, does not teach an electromechanical physical neural network system. McHardy's abstract does, however, refer to an electrochemical synapse. McHardy, C1, L8-12, for example, provides no teaching of an electromechanical physical neural network system. Applicant's invention is clearly electromechanical in nature. McHardy is clearly electrochemical.

The McHardy synapse utilizes an electrochemical a process to achieve connection variation. The chemical process is fundamental to its operation and described in detail throughout McHardy, and is stated as a limiting aspect of the McHardy invention in every single claim of McHardy. The balancing electrochemical

reactions are shown clearly (e.g., see C5 L40-65 of McHardy) and make use of pH changes at the anode and cathode by the electrolyses of water. McHardy is thus clearly an electrochemical device/process. An electrochemical process or device requires electrolysis. Applicant's invention does not.

By stark contrast, the Applicant's invention is ***electromechanical***. Unlike McHardy, chemical bonds are not broken nor made during Applicant's device operation. The dipole-induced aspect of Applicant's invention acts to accumulate nanoconductors between electrodes to facilitate electrical conduction. Although Applicant's connection could be built with water, the electrolysis that makes the McHardy synapse viable would instead degrade Applicant's synapse by creating hydrogen and oxygen gas. The electrochemical nature of McHardy clearly teaches away from the electromechanical-based teaching of Applicant's invention.

The device of McHardy is also limited to the use of migratable metals. For example, see McHardy at Col. 4, line 7, wherein McHardy refers to "migratable metals such as copper, bismuth, silver etc." The Applicant's invention, on the other hand, can use non-migratable materials, configured as nanoconductors such as, for example, carbon nanotubes, gold nanowires, gold nanoparticles, latex spheres, DNA, etc. In the Applicant's invention, an electric field affects such nanoparticles by inducing a dipole force. Applicant's specification indicates that "...dipole should preferably be induced in the material when in the presence of an electric field." That is, the dipole is induced in the nanoparticle/nanoconductor, which in turn causes a force towards regions of high field gradient such as the connection gap described and claimed by Applicant. Note that the direction of a dipole induced force is not necessarily the direction of the applied electric field. The electrical conduction between electrodes that form the electrode gap is regulated by the presence of nanoparticles (i.e., nanoconductors) at or near the connection gap. This process, which is set forth in Applicant's claims, is thus electro**mechanical**.

The use of *ions* by McHardy, on the other hand, is an electro**chemical** process. McHardy teaches "...parallel electrode reactions involving the water present in the electrolytic solution provided by the absorbed moisture" (see Col. 4, lines 21 of McHardy). It is important to understand that McHardy requires the use of chemical reactions at the electrodes. See, for example, the chemical reactions indicated at Col. 5, lines 41-42 and Col. 5, line 45 and also Col. 5, line 60 of McHardy.

The Applicant's invention is an electromechanical device that utilizes nanoconductors (e.g., nanotubes, nanowires, nanoparticles, carbon granules or bearings, DNA, latex, silicon, etc). A few examples of such nanoconductors are indicated in Applicant's claims 26-30.

Each nanoconductor is an assembly of multiple atoms that does not necessarily possess a net charge, unlike an ion. McHardy, on the other hand, is clearly limited to the use of metallic ions in an electrochemical process/device. McHardy relies upon the use of a migratable metal (see Col. 4, lines 1-3 of McHardy) as part of an electroplating process. A migratable metal as taught by McHardy is a metal that is ionized via the electrolytic medium of McHardy. One feature that is particularly important to the electrochemical basis of McHardy is that the solubility of the metal ions of McHardy is dependent on the pH of the electrolytic medium of McHardy (see Col. 4, line 38 of McHardy and Col. 4, line 55-65 of McHardy). The pH is in turn controlled by chemical reactions taking place at the electrodes. (See, for example, McHardy Col. 4, line 37 to Col. 6, line 11, where such chemical reactions and processes are described).

Applicant's invention, on the other hand, is not based on the use of migratable metals as required by McHardy's electrochemical processes and components. In fact, McHardy states clearly that gold is a non-migratable metal (i.e., see Col. 3, line 68 of McHardy). The gold utilized by McHardy is used for one of McHardy's terminals, but not for any actual "nanoconductors". This is a

significant difference form Applicant's invention in which gold nanoparticles, for example, can be used in a dielectric solution to form a synapse via Applicant's dipole-induced force, which is independent of voltage polarization. The interaction of the dipole-induced force, Applicant's dielectric medium and Applicant's nanoconductors (i.e., carbon nanotubes, carbon nanowires, DNA, etc) is an electromechanical-based configuration and/or process.

Another significant difference between McHardy and Applicant's invention is the fact that the liquid dielectric solution of Applicant's invention possesses an electrical conductance that is less than the electrical conductance of the nanoconductors suspended and free to move about in the liquid dielectric solution.

Additionally, McHardy teaches a solid-state device based on solid-state electrochemistry (e.g., see Col. 2 lines 50-54 of McHardy). The moisture film of McHardy is absorbed on McHardy's permanent interconnection as part of the electrochemical process described McHardy (e.g., see 55-60 of McHardy). If the moisture film was not absorbed in the manner taught by McHardy, then McHardy would not function as a solid-state device. McHardy, however, is plainly a solid-state device. Applicant's device, on the other hand, is not a solid-state based device due to the use of a liquid dielectric solution. The use of the liquid dielectric solution by Applicant renders the Applicant's device a non-solid-state device. That is, a liquid is not a solid.

McHardy also requires a permanent interconnection or permanent interconnect. Applicant's invention, on the other hand, does not use a permanent interconnect. The ability of Applicant's connections to strengthen or weaken and/or dissolve back into the liquid dielectric solution (e.g., see Applicant's claims 37-38) means that the connection network is not permanent. In fact, Applicant's claim 42 actually indicates that the connection network is an impermanent connection network.

One of the reasons (but not the only reason) that the permanent interconnect of McHardy renders the McHardy device a solid-state device because the moisture film is absorbed by the permanent interconnection. The moisture film, once absorbed by McHardy's permanent interconnection, is then essentially gone. This functionality is clearly evidence of a solid state device The use of the dielectric liquid solution of Applicant's invention, on the other hand, renders Applicant's device a non solid state based device; that is a liquid is not a solid. More importantly, McHardy does not teach, disclose or suggest a liquid dielectric solution comprising a mixture of a dielectric solvent and said plurality of nanoconductors disposed and free to move about in said liquid dielectric solution.

McHardy fails to teach a number of other of Applicant's claim limitations. For, example, McHardy does not teach, suggest or disclose applying an electric field across said connection gap applies a voltage across a space occupied by said liquid dielectric solution to configure and arrange said connection network, said voltage comprising a DC voltage or an AC voltage that when applied across said liquid dielectric solution gradually forms said interconnected nanoconnections of said plurality of interconnected nanoconnections in said liquid dielectric solution within said connection gap between said at least one pre-synaptic electrode and said at least one post-synaptic electrode. Instead, McHardy is limited exclusively to a DC voltage and does not allow for the alternative possibility of the use of AC. One skilled in the art would realize that the use of AC would actually damage or destroy the McHardy device and prevent the electrochemical process of McHardy from functioning,

McHardy also does not teach, suggest or disclose that the longer the amount of time said electric field is applied across said connection gap and/or the greater the frequency or amplitude of said electric field applied across said connection gap, the more nanoconductors among said plurality of nanoconductors align and the

stronger said interconnected nanoconnections among said plurality of nanoconnections become.

McHardy further does not teach, suggest or disclose a feedback mechanism connected to and associated with said connection network, wherein said feedback mechanism together with said connection network comprise a multi-layer, feed-forward network.

McHardy also does not teach, suggest or disclose a feedback mechanism connection to said connection network that provides for a Hebbian synapse modification that permits said connection network to function as a recurrent and highly interconnected network.

McHardy also does not teach, suggest or disclose a learning mechanism connected to said connection network to train said electromechanical neural network system. McHardy also not teach, suggest or disclose an STDP (Spike-Timing Dependent-Plasticity) training rule.

McHardy also does not teach a weak alternating electric current perpendicular to said plurality of interconnected nanoconnections, which causes at least some of said plurality of interconnected nanoconnections not contributing to a desired output to weaken and eventually dissolve back into said liquid dielectric solution, thereby allowing for an increased flexibility in a continuous training of said electromechanical neural network system utilizing said training mechanism.

McHardy further fails to teach, suggest or disclose wherein at least some of said interconnected nanoconnections among said plurality of interconnected nanoconnections are weakened by increasing a temperature of said liquid dielectric solution, which causes at least some of said plurality of interconnected nanoconnections not contributing to a desired output to weaken and eventually dissolve back into said liquid dielectric solution, thereby allowing for an increased flexibility in a continuous training of said electromechanical neural network system utilizing said training mechanism.

McHardy further fails to teach, suggest or disclose at least one base neuron in a perpendicular array structure composed of a plurality of neural network layers coupled with said plurality of synapses comprising said plurality of interconnected nanoconnections of said connection network, wherein each synapse among said plurality of synapses comprises a plurality of connections conduits separated by a particular distance wherein each connection conduit among said plurality of connection conduits is a result of said plurality of nanoconductors aligning in the presence of said electric field, wherein said electric field is generated by a temporal and sequential firing of said at least one base neuron.

McHardy also fails to teach, suggest or disclose a dielectric solvent comprising a volatile liquid and an air-tight seal for confining said liquid dielectric solution within said connection gap to prevent said volatile liquid from coming into contact with air.

McHardy further fails to teach, suggest or disclose a gate located adjacent said connection gap, and insulated from electrical contact by an insulation layer, wherein said gate is connected to logic circuitry which can activate or deactivate at least one synapse among said plurality of synapses utilizing a gate voltage provided by said gate, whereby a resistance between said at least one pre-synaptic electrode and said at least one post-synaptic electrode is modifiable by aligning said plurality of nanoconductors in said liquid dielectric solution when said electric field is applied across said connection gap and comprises an alternating electric field.

As further direct evidence that the device, as described by McHardy, bears no similarity to Applicant's invention, one only need look at the title of the McHardy reference: "**Electrochemical** synapses for artificial neural networks". McHardy is based on electrochemical processes. Applicant's invention, on the other hand, as indicated previously is **electromechanical in nature**. That is, electrochemical processes do not occur with respect to Applicant's neural network device, which

instead is based on electromechanical functions (e.g., conductors, dielectric, electrodes, etc).

The device, as described by McHardy, on the other hand, teaches the following ***electrochemical*** processes (see McHardy, C1, L46-55 and C3, L8-10):

"Metal migration is an electrochemical process related to electroplating. Metal migration takes place between conductors in an active electronic circuit in the presence of a moisture film. Under the influence of a DC voltage, metal ions dissolve from the positive conductor (the anode). The dissolved ions migrate through the moisture film (the electrolyte) and plate out on the negative conductor (the cathode). The deposit often takes the form of metallic whiskers which eventually reach the anode and create an ohmic contact."

And

"As another feature of the present invention, permanent interconnects are provided which include mixed halides of rubidium with copper or silver."

Applicant's invention does **not** utilize the metal migration process of McHardy, which requires, 1) a DC voltage, 2) metal ions, 3) a permanent connection between pre- and post-synaptic electrode that forms the cathode and 4) a reversed-biased voltage that induces chemical reactions that affect the pH of the electrolytic solution and in turn weakens the connection.

Applicant's invention 1) does NOT require (but can use) a DC voltage, but will also work with AC; 2) does NOT require metal ions, but rather can use charge neutral particles such as nanoconductors (e.g., nanotubes, nanowires, nanoparticles, DNA, etc); 3) does NOT require permanent connection between pre- and post-synaptic electrodes, but builds this connection from the nanoparticles; and 4) does not weaken connections via an electronically induced chemical process, but rather the purely electromechanical process of random thermal motion also known as Brownian motion as described by Einstein.

Thus, there are in fact significant differences in the physics between Applicant's invention and McHardy's device, in addition to incredible differences in

the manner in which the devices are controlled. For example, McHardy does not teach controlling a neural network using the liquid dielectric solution of Applicant's invention, which is what occurs in the electromechanical physical neural network of Applicant's invention.

Additionally, McHardy relies upon the use of a single permanent interconnect 16 (see FIG. 1 of McHardy) that forms an electrolytic path for ions, NOT charge neutral particles, between the input terminal 12 and the output terminal 14 of McHardy (see column 3, lines 50-52 of McHardy). An electrolytic medium is not a dielectric medium: one exists for the movement of ions to promote electrical conduction (electrolytic); the other is used specifically for its properties of canceling electric fields and inhibiting electrical conduction (dielectric). An electrolytic medium involves the use of an electrolyte and not a dielectric. McHardy provides no teaching, suggestion or disclosure of a dielectric, and particularly a liquid dielectric solution composed of a mixture of nanoconductors AND a dielectric solvent. Conductors referred to by McHardy do not constitute a dielectric solvent. Additionally, the moisture film of McHardy is not a liquid dielectric solution comprising a mixture of nanoconductors and a dielectric solvent. McHardy is based on the electrolytic path (interconnect 16) and hence an electrolyte, not a dielectric.

The Applicant additionally notes that for the same reasons provided above, McHardy does not anticipate, teach or suggest all of the following claim limitations of Applicant's claim 42-44:

42. A method of forming an electromechanical neural network system based on nanotechnology, comprising:

providing a liquid dielectric solution comprising a mixture of a dielectric solvent and a plurality of nanoconductors, wherein each nanoconductor among said plurality of nanoconductors is suspended and free to move about in said liquid dielectric solution;

forming a connection gap between at least one pre-synaptic electrode and said at lease post-synaptic electrode;

configuring a connection network to comprise said plurality of nanoconductors suspended and free to move about in said liquid dielectric solution located within said connection gap formed between said at least one pre-synaptic electrode and said at least

one post-synaptic electrode, wherein said connection network comprises an impermanent interconnect between said at least one pre-synaptic electrode and said at least one post-synaptic electrode;

configuring said connection network to comprises a plurality of interconnected nanoconnections with said connection network, wherein said plurality of interconnected nanoconnections comprise said plurality of nanoconductors in said liquid dielectric solution, said plurality of interconnected nanoconnections electrically connecting said at least one pre-synaptic electrode to said at least one post-synaptic electrode through said liquid dielectric solution and said plurality of nanoconductors disposed within said liquid dielectric solution; .

providing a plurality of synapses from said connection network, wherein said plurality of synapses comprises said plurality of interconnected nanoconnections of said connection network and wherein each synapse among said plurality of synapses is independent of voltage polarization; and

applying an electric field across said connection gap, whereby said electric field induces a dipole in each nanoconductor among said plurality of nanoconductors only when said plurality of nanoconductors is located within said liquid dielectric solution, thereby aligning said plurality of nanoconductors within said liquid dielectric solution and strengthening or weakening each nanoconnection among said plurality of interconnected nanoconnections according to an application of said electric field across said connection gap..

43. (New) The method of claim 42 wherein the longer the amount of time said electric field is applied across said connection gap and/or the greater the frequency or amplitude of said electric field applied across said connection gap, the more nanoconductors among said plurality of nanoconductors align and the stronger said interconnected nanoconnections among said plurality of nanoconnections become.

44. (New) The method of claim 42 further comprising training said electromechanical neural network system utilizing an <u>STDP</u> (Spike-Timing Dependent-Plasticity) training rule.

III. Conclusion

The Applicant has clarified the structural distinctions of the present invention via the amendments submitted herewith. Such amendments are enabled and support by Applicant's specification and do not constitute new matter. Reconsideration and allowance of Applicant's application is therefore respectfully solicited.

Should there be any outstanding matters that need to be resolved, the Examiner is respectfully requested to contact the undersigned representative to

conduct an interview in an effort to expedite prosecution in connection with the present application.

Respectfully submitted,

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